Observations on Crabapple Creek Estuary and Bearskin Bay, Queen Charlotte Islands with Recommendations for Remediation of Fish Habitat Damaged and Stressed from Log Handling Operations Including Fuel Oil Spills

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OBSERVATIONS ON CRABAPPLE CREEK ESTUARY AND BEARSKIN BAY, QUEEN CHARLOTTE ISLANDS WITH RECOMMENDATIONS FOR REMEDIATION OF FISH HABITAT DAMAGED AND STRESSED FROM LOG HANDLING OPERATIONS INCLUDING FUEL OIL SPILLS

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ABSTRACT

Levings, C.D. 2002. Observations on Crabapple Creek estuary and Bearskin Bay, Queen Charlotte Islands with recommendations for remediation of fish habitat damaged and stressed from log handling operations including fuel oil spills. Can. Data Rep. Fish. Aquat. Sci. 1095: 11p.

Observations are presented from field reconnaissance in August 2000 of estuaries and nearshore fish habitats in Skidegate Inlet, especially at the Crabapple Creek estuary on Bearskin Bay near Queen Charlotte City, Graham Island, B.C. Recommendations for remediation of fish habitat damaged and stressed from log handling operations at Bearskin Bay, including fuel oil spills, are also given.

RÉSUMÉ

Levings, C.D. 2002. Observations on Crabapple Creek estuary and Bearskin Bay, Queen Charlotte Islands with recommendations for remediation of fish habitat damaged and stressed from log handling operations including fuel oil spills. Can. Data Rep. Fish. Aquat. Sci. 1095: 11p.

Ces observations sont tirées de travaux de reconnaissance effectués en août 2000 dans les estuaires et les habitats du poisson du littoral, dans le passage Skidegate, et plus précisément dans l'estuaire du ruisseau Crabapple, dans la baie Bearskin, près de la ville de Queen Charlotte, sur l'île Graham, en Colombie-Britannique. Nous recommandons aussi des mesures correctives en ce qui concerne l'habitat du poisson qui a été endommagé et perturbé par les activités de manutention du bois dans la baie Bearskin, y compris les déversements de pétrole.

INTRODUCTION

In August 2000, Habitat and Enhancement Branch (HEB) and Conservation and Protection (C&P) staff requested scientific assistance with a court case relating to effects of a fuel oil spill (1997) in the Crabapple Creek estuary and nearby Bearskin Bay, on the Queen Charlotte Islands. In anticipation of possible remediation measures for damaged fish habitat, HEB and C&P staff required an ecological assessment of the effects of the spill together with other cumulative effects in the estuary, especially log storage. The present author conducted a literature search and also carried out a field survey of the area on August 27 and 28, 2000. The field work included shoreline observations by boat in Skidegate Inlet from Sandspit and Skidegate Village west to Deanna River and Outlook Creek, east of Lena Narrows. Detailed observations of the intertidal zone of Bearskin Bay and the Crabapple Creek estuary were conducted on foot at low tide. It is hoped publication of this material may be useful for future ecological assessments and restoration projects in the area.

REGIONAL SETTING OF CRABAPPLE CREEK ESTUARY

Crabapple Creek flows into Bearskin Bay, on the outskirts of Queen Charlotte City, B.C. which in turn is located on Skidegate Inlet, one of the major inlets on the west side of Hecate Strait. Characterized by relatively high wave energy, with ocean swells from Hecate Strait, outer Skidegate Inlet is considered an exposed habitat. Seaward of Bearskin Bay, towards Hecate Strait, outer Skidegate Inlet shorelines are relatively straight and characterized by steep rocky shores (south side of Graham Island) or low profile sandy or gravel beaches (north side of Moresby Island). Only a few streams (e.g. Sachs Creek) bring freshwater to this part of the Inlet.

In contrast, the shorelines of inner Skidegate Inlet are lengthy and convoluted, and several rivers and creeks discharge freshwater to the area. Bearskin Bay with its estuaries, islands, embayments, and channels add significantly to the perimeter length of the shoreline of inner Skidegate Inlet. As described below, young salmon produced in numerous rivers migrate to Hecate Strait, and hence to the Pacific Ocean, along the shallow water shorelines of inner Skidegate Inlet. Bearskin Bay is the last complex of estuarine habitat on the north side of the inlet that the young salmon have available to them before encountering open coastal habitats. The shoreline of Bearskin Bay is characterized by a mixture of estuarine beach types including mud, sand, gravel, and rocky shores. Wave energy in this area is low.

ECOSYSTEM OF CRABAPPLE CREEK ESTUARY AND BEARSKIN BAY

HABITATS AND VEGETATION

Several creeks or small rivers drain into Bearskin Bay, including Honna, Carson Bigelow, and Crabapple Creeks, as well as a number of smaller unnamed streams.

Crabapple Creek, a stream about three km long, is a typical coastal system with maximum flow in fall and winter from rainfall. The discharge of freshwater has allowed the development of a productive estuarine ecosystem at the creek mouth, characterized by plants and animals adapted to brackish water. These brackish water plants are dominant at the higher elevations of the intertidal zone. This is because fresh water from Crabapple Creek remains at the surface of the water and is pushed landward at high tide. Further seaward at the estuary, at lower elevations, plants and animals adapted to more saline conditions are found. Sediments along the entire intertidal zone at the estuary are characterized by mud and sand, with rock and shale outcrops in a number of locations. For shoreline classification purposes, the estuary of Crabapple Creek has been classified as a protected, sand and gravel flat (Environmental Mapping Ltd. 1999).

FOOD WEBS

The shallow waters and intertidal zones of inlets and fjords on the Queen Charlotte Islands are important migratory and rearing habitats for young salmon (e.g. Stockner and Levings 1982; Yakoun River estuary). While the young salmon are in this migratory phase, they are reliant on a food web that has its base on the algae, eelgrass, and marsh plants of the estuaries. The feeding ecology of young salmon in estuaries was established over 20 years ago and the ecological value of the plants is well recognized in the international scientific literature (e.g. Levings 1994). Vascular plants, eelgrass, and algae observed in August 2000 and earlier surveys (Cowan 1998) at the Crabapple Creek estuary are described in Table 1. The decomposing plant material, combined with bacteria, is called detritus, a food substance that is well recognized as a source of food for invertebrates, such as amphipods. These invertebrates are in turn fed upon by young salmon in fry and smolt stages as they migrate through Bearskin Bay on their way to the sea. Other fish species in addition to salmon are also reliant on this food web, as described below.

Table 1. Zonation of dominant plants in Crabapple Creek estuary.

Zone	Substrate	Biota
High Intertidal and Riparian	Predominantly gravel bed, bedrock outcrops	Terrestrial grasses and plantain (*Plantago* spp.), sedges (*Carex* spp.); riparian shrubs (*Alnus* spp.)
Upper Intertidal	Mud/ gravel bed	Pickleweed (*Salicornia virginica*)
Mid-Tidal	Gravel bed channel; mud flats; elevated shale and rock outcrops	Rockweed (*Fucus* spp.); Bladed green algae (*Ulva*/ *Enteromorpha*-type) Filamentous green algae.
Low Intertidal	Gravel bed; low, silt-sand banks	Eelgrass (*Zostera marina*)

RESOURCES SUPPORTED BY THE ECOSYSTEM OF CRABAPPLE CREEK ESTUARY AND BEARSKIN BAY

SALMONIDS

Six species of salmon utilise the habitats of the Crabapple Creek estuary and Bearskin Bay foreshore. Each species uses the estuary or foreshore twice during their life cycle: once they migrate to the ocean as fry or smolts and again when they return to Inner Skidegate Inlet as adults. Salmonids documented in Crabapple Creek are as follows: chum salmon (*Oncorhynchus keta*), coho salmon (*O. kisutch*), Dolly Varden char (*Salvelinus malma*) and cutthroat trout (*O. clarki*) (FISS 2000; Cowan 1998). Pink salmon (*O. gorbuscha*) spawn in Honna River and returning adults move along the foreshore of Bearskin Bay as they migrate from outer Skidegate Inlet to the creek mouth. Pink salmon fry move through estuaries quite quickly but use shallow water foreshores such as those in Bearskin Bay on their seaward migration. Chum and coho salmon use the Crabapple Creek estuary twice during their life cycle: once when they migrate seaward as fry or smolts, and again as adults when they return to Crabapple Creek to spawn. In recent years, approximately 1200 chum salmon and 50 coho salmon have spawned in the lower reaches of Crabapple Creek (Cowan 1998). The progeny of these fish, as well as those from nearby streams, are directly dependent on Crabapple Creek estuary and Bearskin Bay for growth and survival. The chum fry migrate into the estuary in spring (April to June) at a length of about 35-40 mm and then move to the ocean when they are approximately 65-70 mm. Coho fry are found in the Crabapple Creek estuary for longer periods, and are present throughout the spring and into the late summer (August). In winter, the coho fry move back into fresh water and then migrate through the estuary again as smolts in the following spring.

Nearshore habitats are particularly important for chum salmon fry, as they remain in estuaries and feed on the detrital-based food web for several weeks (Sibert et al. 1977). Dolly Varden char and cutthroat trout are also part of estuarine food webs as they feed on chum and coho fry as well as invertebrates. The coho fry I observed feeding in the estuary and lower creek likely originate from Crabapple Creek itself, as well as possibly adjacent streams such as Honna, Outlook, and Carson Bigelow Creek.

OTHER FISH SPECIES

The foreshores of Inner Skidegate Inlet are important for spawning herring (*Clupea harengus pallasii*) which lay their eggs on eelgrass and a variety of algae such as rockweed. Spawning along the north shore of Skidegate Inlet appears to be limited to the area immediately east of the Crabapple Creek estuary (Hay and McCarter 2000). The causeway constructed for a log sorting area may be related to this (see below). The relatively late season of the spawning (mid-May) indicates Skidegate Inlet supports a distinct stock (Hay et al. 1989). Low and Peacock (1990) conducted a survey of the subtidal area of eelgrass-dominated habitat in Shingle Bay in outer Skidegate Inlet near Sandspit. Some marine fish species documented in that survey are also likely present in Bearskin Bay. The six species found were Painted greenling (*Oxylebius pictus*), Kelp

greenling (*Hexagrammos decagrammus*), Shiner seaperch (*Cymatogaster aggregata*), Starry flounder (*Platichthys stellatus*), and C-O sole (*Pleuronichthys coenosus*). All of these species are directly or indirectly dependent on the detrital food web described above.

SHELLFISH AND CRUSTACEANS

Several species of potentially harvestable shellfish and crustaceans are present in inner Skidegate Inlet. The following shellfish species have been found in Crabapple Creek estuary and Bearskin Bay foreshore: blue mussels (*Mytilus trossulus*); butter clams (*Saxidomus gigantea*), horse clams (*Tresus capax*), littleneck clams (*Protothaca staminea*), and basket cockles (*Clinocardium nuttalli*). Larger crustaceans found in the estuary include rock crab (*Cancer gracilis*) and shore crabs (*Hemigrapsus nudus*). Numerous other smaller invertebrate species are important in food webs, such as the amphipods referred to above. Other prominent larger invertebrates observed in the Crabapple Creek estuary are barnacles (*Balanus glandula*), burrowing anemones, and lugworms.

CHRONIC AND ACUTE STRESS ON CRABAPPLE CREEK ESTUARY AND BEARSKIN BAY

The ecosystems of Crabapple Creek estuary and Bearskin Bay have been subjected to several destructive events which have caused acute and chronic stress. All of these stressors have been directly or indirectly related to forestry activities. The estuary has been subjected to chronic stress from log watering and log boom storage over at least 50 years of activity. In addition, while the estuary was used as a log booming/sorting area (est. 1950 to 1997) there were likely frequent small oil spills from fueling of boats and trucks. The most recent acute effect is the spill of diesel oil from a leaking pipeline that brought oil to a logging truck fuel depot near the creek mouth. This oil spilled directly into the estuary on May 16-17, 1997, as described below. However, it is possible there has been chronic effects from pipeline leakage because there is some information that fuel oil had been leaking into groundwater near the estuary for several years before that.

CHRONIC EFFECTS

Dry Land Sort and Causeway Construction

Construction of a log dump facility at the west side of the Crabapple Creek estuary about 50 years ago and a dry land sort in 1965 has resulted in the direct loss of approximately 1.5 ha of intertidal habitat by filling of shallow water habitat. The causeway for the log dump was built by dumping rock and soil to connect several intertidal rock outcrops. Filling permanently alienates estuarine ecosystems and affected areas cannot function for fish food production (Levings 1980; Levings and Moody 1976). In addition, there is direct loss of shallow water for fish to live in during their critical

early life history phases. Spawning habitat for herring has also been permanently lost. Causeways change water circulation patterns (Levings 1980). In Bearskin Bay, the causeway prevents the flow of freshwater flow from Crabapple Creek to the east, and as well impedes the flow of incoming tidal currents from outer Skidegate Inlet moving west These works create a barrier to the migratory patterns of salmon fry and smolts moving seaward, toward Hecate Strait, from Crabapple Creek and Honna River. In addition, the inshore spawning migrations of adult herring, moving west from Hecate Strait have also been impaired.

Chronic Oil Leakage into the Estuary

Based on observations of the smell and taste of water from lower Crabapple Creek, there is some information showing that leakage of oil from the fuel depot pipelines into groundwater near the estuary may have been ongoing since 1993 (Cowan 2000). It is not known to what extent this oil penetrated into the groundwater and sediments in the estuary (Dr. W. Cretney, Institute of Ocean Sciences, personal communication). In addition, small spills from dozer boats and tugs involved in log booming likely occurred over the years. Fuel oil is well recognized as a deleterious substance and numerous authors have documented effects on estuarine fish as well as damage to critical components of the estuarine ecosystem (Teal et al. 1992; Ho et al. 1999).

Chronic Wood Waste Effects

In August 2000 wood and bark waste from log watering operations were still evident in the low intertidal zone below the ramps on the southwest side of the dry land sort. While the log sort was in operation, bundled logs were skidded down the ramps and in the process bark, branches, and chips were lost in the water and sank to the bottom. Approximately 0.5 ha of estuarine habitat was severely affected by decomposing bark, branches, and chips (see Fig 15 1a in Levings and Northcote 2003). The area was characterized by heavy odour of toxic hydrogen sulfide, indicating an environment with very low dissolved oxygen concentrations. The decomposing wood was at least 20 cm deep, and in some places much thicker. Eelgrass was totally absent from the affected area, as were invertebrates such as shore crabs, barnacles, and mussels. These organisms were present on the beach further west where wood debris was not found.

Effects of wood waste debris from log dump operations have been documented in numerous studies and in general show that waste wood, especially bark and chip "mulch", has a deleterious effect on estuarine ecosystems (e.g. Conlan and Ellis 1979; Williamson et al. 2000; Levings and Northcote 2003). Smothering of natural sediments by wood debris prevents the successful survival of invertebrate larvae and because of behavioural avoidance reactions (Chang and Levings 1976) organisms such as shrimp and crab will avoid wood polluted sediments. Sublethal effects from hydrogen sulfide associated with log waste have been documented on Dungeness crab (O'Clair and Freese 1988). During coastal log processing operations, suspended wood debris concentrations

in the range 9 -170 mg·L^{-1} are likely in surface water (Magor 1988). These concentrations have been related to gill damage in coho salmon smolts (Magor op cit).

ACUTE EFFECTS OF A FUEL OIL SPILL ON MAY 16-17, 1997

On May 16 and 17, 1997, pools of fuel oil were observed in lower Crabapple Creek (Cowan 2000). On the east bank of the Creek, close to the estuary, fuel oil leaked from soil above the streambed. The oil then flowed into the creek and onto the intertidal zone of the estuary. About 100-150 L were spilled into the estuary during the 12 h period between the evening of May 16 and the morning of May 17 when cleanup started.[1] Dead and stressed chum salmon fry were observed in the low tide channel of the estuary. The fish kill observed in the Crabapple Creek estuary on May 16-17, 1997 was a clear manifestation of the acute toxicity of fuel oil and was consistent with laboratory studies on the toxicity of fuel oil to juvenile salmon (Rice et al. 1976). Tainting is an another well recognized effect of oil spills. There is no information on whether harvestable organisms, such as crabs and clams, were rendered inedible by the spill; however, there is a possibility that the taste and smell of shellfish in the estuary was affected.

The fuel oil spill caused stress to other elements of the ecosystem as this contaminant has been shown to be toxic and have sublethal effects on algae, marsh plants, and invertebrates such as fish food organisms (Antrim et al. 1995; Ho et al. 1999; Hampson and Moul 1978). In general, refined products such as diesel oil are more toxic than crude oils due to their higher content of lightweight polycyclic aromatic compounds. The acute effects observed during the Crabapple Creek spill are therefore in agreement with biological effects described elsewhere. Acute toxicity appears to be related to the content of soluble aromatic derivatives such as benzene, naphthalene, phenanthrene, and their alkyl homologs (Neff and Anderson 1981). Fish survival is directly affected by fuel oils. Hughes (1999) estimated that survival of winter flounder embryos was reduced by 51 % by fuel oil spilled into an estuary.

Oil spill booms and absorbent pads were deployed by staff of a forestry company in the upper Crabapple Creek estuary on the morning of May 17, 1997 (Cowan 2000). This was an effort to recover oil from the surface waters of about 50 m of tidal channel habitat. While the cleanup helped reduce stress on the ecosystem and may have minimized the number of fish killed by the oil, there are no data on how effective the cleanup was. Sensitivity rankings based on biophysical attributes and marine resources identify Skidegate Inlet as an environmentally sensitive area to oil spills in the Queen Charlotte Islands (Petro-Canada 1983). The lower wave energy environment of Bearskin Bay increased exposure time of the ecosystem to the oil spill effects, with decreased dissipation from evaporation, photo-oxidation and bacterial activity relative to an open ocean environment such as Hecate Strait. In addition, sedimentation and burial of the

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[1] Precise measurements of the spill volume are not available. My approximation is based on photographic estimates of the number of absorbent pads used in the cleanup (photos taken by Mr Allan Cowan, DFO, on May 17 1997). An estimate of about 300 L using chemical and hydrologic calculations was made by Dr. Walter Cretney at the Institute of Ocean Sciences, Sidney).

fuel oil through adsorption to fine-grained particles may have resulted in slower degradation due to potentially lower oxygen concentrations and entrapment of oil by estuarine circulation. Estuaries have high oil retention potential due to their sand and gravel material and low wave exposures (Environmental Mapping Ltd. 1999).

The streambed of the lower 30 m of the creek was excavated to remove sediment contaminated with fuel oil from chum salmon spawning habitat and replaced with clean substrate of various sizes. Use of the replacement substrate by spawning salmon has not been documented however (Cowan 1998). A soil remediation program was being conducted in 2000for the upland soil dug out from the stream bank of Crabapple Creek. Grasses and small alder were planted on the disrupted stream bank, but riparian vegetation has not been restored to the original state. The soil remediation program did not deal with any estuary sediment.

RECOMMENDED HABITAT REMEDIATION FOR CRABAPPLE CREEK ESTUARY AND BEARSKIN BAY

The Crabapple Creek and Bearskin Bay estuarine ecosystem has been badly damaged by forestry-related impacts over the past 50 years. However, all the industrial activity (log transport, dumping, sorting, and booming and related fuelling) connected with the forestry industry at Bearskin Bay ceased in 1997. Therefore, a comprehensive remediation or restoration plan, together with an ecological monitoring program, should be developed and implemented to recover Crabapple Creek estuary and Bearskin Bay as a productive fish habitat system. The key priority items are given in Table 2.

A suitable goal or objective would be to remove the present stressors and recreate the landscape of the ecosystem, using an undamaged estuary in Inner Skidegate Inlet (e.g. Deena River estuary) as a model. Some restoration activities should be started immediately, as they are obvious and have been proven successful in other estuaries in British Columbia. As examples, the Campbell River estuary has been recovered from log storage impacts (Brownlee et al. 1984), dike breaching from a logging railroad causeway in the Kokish River estuary restored circulation in that ecosystem (Campbell and Bradfield 1988), and marsh habitats in Delkatla Slough near Masset were restored when a causeway was opened (Morris 1997).

Information on the recovery status of Bearskin Bay and Crabapple Creek and estuary ecosystem from acute (May 1997) and possible chronic oil leakage (1993-1997) from the truck fuel depot pipeline should be a key component of the restoration plan. The condition of the ecosystem needs to be verified by field data and comparison with an undisrupted estuary. In particular, the productivity of key ecosystem elements, such as marsh plants and algae, should be assessed to evaluate any long term effects. Tests should also be conducted if resident organisms, such as shellfish, are still under stress from oil pollution. It is also important to determine if they are tainted by fuel oil. A survey should be done to determine the distribution and amount of fuel oil in the groundwater of the estuary. In an estuary in Massachusetts, some fuel oil was found in

marsh sediments 20 years after a spill (Teal et al. 1992). The same situation may be occurring at the Crabapple Creek estuary, and this needs to be investigated. Chronic pollution may still be occurring as there is uncertainty about how much oil remains in the groundwater aquifers at the estuary. If significant amounts are found, specific soil mediation may have to be undertaken in the estuary, as was done for upland soils near the creek mouth. The riparian vegetation destroyed in the upland soil remediation program also needs to be completely restored.

Table 2. Key priorities for habitat restoration at Bearskin Bay and Crabapple Creek and estuary.

Item
Sampling of sediment and organisms for evidence of remnant oil, sublethal effects (vegetation productivity, histopathology), and tainting
Dredging of waste wood and polluted sediment, southwest side of dry land sort, land disposal, evaluation
Option A: Breaching of causeway at two locations, evaluation
Option B: Total removal of causeway and dry land sort to return habitat to original elevation, transplant vegetation to stimulate natural colonization, evaluation
Replanting of riparian vegetation in lower Crabapple Creek, evaluation of spawning on replaced substrate

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